1. BACKGROUND

Multi-decadal trend of the Indian Ocean vertical warming structure shows a complex pattern: near-surface warming is accompanied by thermocline cooling in the tropical south Indian Ocean. This intricate pattern of temperature variability is consistent with the distinct spatial patterns of sea level trends since the 1980s. The sea level drops in the southwestern Indian Ocean and rises elsewhere. Overlying on the multi-decadal trend, large-amplitude decadal variability has been observed for Indian Ocean SST, sea level, and upper ocean heat content. What is the relative importance of winds over the Indian Ocean versus that over the Pacific in causing decadal variability of sea level and thermocline depth in the South Indian Ocean? What is the role of Indian Ocean internal variability? Answering these questions is important, because understanding the causes and improving the estimates of spatially varying sea level change are important research targets in coming years.

2. GOAL AND APPROACH

The goal of this study is to assess the relative importance of winds over the Indian Ocean versus winds over the Pacific via the Indonesian Throughflow (ITF) in causing South Indian Ocean decadal variability of sea level and thermocline depth, and to examine the role of Indian Ocean internal variability. To achieve the goal, three sensitivity experiments (see Table 1) are performed using an Ocean General Circulation Model (OGCM), the HYbrid Coordinate Ocean Model (HYCOM).

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Forcing Fields</th>
<th>Assessed Processes for decadal variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDOPAC</td>
<td>3-day mean ERA-40 fields from 1958-2001; 3-day QuikSCAT winds, pentad CMAP precipitation, ISCCP radiation for 2000-2008</td>
<td>All (remote, local, &amp; internal variability)</td>
</tr>
<tr>
<td>IND</td>
<td>Same as INDOPAC except that forcing over the Pacific (Fig. 1a) is kept to climatological mean Indian Ocean wind forcing (also includes effects of internal variability)</td>
<td>Pacific forcing via the ITF</td>
</tr>
<tr>
<td>DIFF</td>
<td>Difference: (INDOPAC – IND)</td>
<td>Oceanic internal variability due to nonlinearity of oceanic system</td>
</tr>
<tr>
<td>INTERNAL</td>
<td>ERA-Interim monthly climatology</td>
<td>same as INDOPAC except that forcing over the Pacific (Fig. 1a) is kept to climatological mean Indian Ocean wind forcing (also includes effects of internal variability)</td>
</tr>
</tbody>
</table>

3. RESULTS

a) Model/data comparison

HYCOM ITF agrees well with INSTANT observed ITF transport, especially for their seasonal-to-interannual variations (2b).

Fig. 3. Linear trends in SSHA for the period 1993-2007 (top row) for (a) AVISO, (b) HYCOM, and (c) SOBA-POP, (shading). Data as in (a) but for the period 2000-2007. Trends are given in cm yr⁻¹. The horizontal line marks the latitude of 11°S.

b) Processes

Decadal change from HYCOM SSH (Fig. 3, middle) agrees well with AVISO data (left), and to a lesser degree, with SOBA data (right). Decadal changes of vertical temperature structure from HYCOM are also reasonably simulated (Fig. 4).

Fig. 4. Decadal zonal mean temperature anomalies for HYCOM (left), SOBA (middle), and WOD05 (right) for the periods 1970-1974 (top), 1975-1980 (bottom), and 1985-1998 (bottom). The bottom panel shows the difference between the 1970-1974 and 1985-1998 periods. The color contours show temperature anomalies, and the line contours show depths of the 25, 20, 18, and 15°C isotherms.

4. Summary & Conclusions

- The vertical structure of decadal temperature variability varies from decade-to-decade, with maximum variability peaking in the vicinity of the thermocline.
- Prior to the early 1990s, decadal variations in sea level and thermocline depth can be described in terms of a baroclinic Sverdrup balance, forced by Ekman pumping velocity associated with windstress curl acting on the Indian Ocean; beginning in the early 90’s, decadal variability of the equatorial Pacific trades forces thermocline variations that modify the sea level and thermocline depth across the tropical south Indian Ocean Basin.
- Further south, between 20°S-30°S, oceanic instabilities make significant contributions to decadal variability of the thermocline.