How do subsurface Tropical Instability Waves in the Atlantic Ocean influence vertical mixing?

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Subsurface Tropical Instability Waves (subTIWs) can cause a vertical two-layer structure above the thermocline with periodically increasing and decreasing shear, which may impact vertical mixing.

Analysis of subTIWs using high-resolution output from the global and comprehensive model ICON-O (Korn, 2017)

ICON-O
• Ocean only setup
• Global and comprehensive
• 10 km horizontal resolution
• 128 vertical levels
• Forced with hourly ERA5 data from 2000 to 2018
• Analysis of daily mean values

Identifying subTIW periods and depth dependence using Power Spectral Density (PSD)

<table>
<thead>
<tr>
<th>Surface TIW periods:</th>
<th>subTIW periods:</th>
<th>Average depth of strongest subTIW energy:</th>
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<tbody>
<tr>
<td>15 – 60 days</td>
<td>15 – 40 days</td>
<td>64 m</td>
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Fig. 1: EOF modes of bandpass filtered (15 – 60 days) TIWs and subTIWs are both generated mainly through barotropic instabilities. Values are normalized and non-dimensional.

I. Difference in forcing of surface TIWs and subTIWs leads to different spatial patterns

- TIWs and subTIWs are generated independently of each other
- Due to the temporally coinciding forcing, both wave types occur at similar times

II. subTIWs can cause a vertical two-layer structure

Two-layer structure with periodically increasing and decreasing vertical shear | Velocity amplitudes: 2 m/s | Onset: May/June | Maximum: August/September

Fig. 2: Bandpass filtered velocity $u'$, $v'$ (top), vertical shear of filtered zonal velocity (middle) and vertical shear of filtered meridional velocity (bottom) during TIW season 2010 at 23° W/0° N (left), 23° W/2° N (middle) and 23° W/2° S (right). Red line in the lower panels indicates the thermocline (20 °C isotherm). Vertical two-layer shear structure is indicated in the middle panel.

III. Differences in subTIW characteristics off and on the Equator

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>$23^\circ W/0^\circ N$</th>
<th>$23^\circ W/2^\circ N$</th>
<th>$23^\circ W/2^\circ S$</th>
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</thead>
<tbody>
<tr>
<td>subTIWs expressed by oscillation of</td>
<td>Zonal velocity</td>
<td>Meridional velocity</td>
<td>Zonal velocity</td>
</tr>
<tr>
<td>~ 60 % of TIW induced shear related to</td>
<td>Zonal velocity</td>
<td>Meridional velocity</td>
<td>Zonal velocity</td>
</tr>
<tr>
<td>Contribution of shear in lower layer relative to vertically averaged TIW induced shear above the thermocline</td>
<td>~ 1/3</td>
<td>~ 2/3</td>
<td>~ 2/3</td>
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Open questions
- How do surface intensified TIWs and subTIWs interact?
- How to quantify the impact of subTIWs on vertical mixing relative to the impact of TIWs?
- How do the model results compare to observations in the tropical Atlantic?

References