STRATIFICATION AND INTERNAL TIDES ON THE AL-BATINAH SHELF

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INTRODUCTION AND METHODS

The Al-Batinah shelf in northern Oman extends between Sohar and Muscat at around 24° latitude and experiences high solar radiation and extreme temperatures in summer. This leads to the development of an intense summer thermocline (Claereboudt, 2018) over the shelf. While the influence of thermal stratification on shelf dynamics has been described for other regions, the involved processes along the Oman coasts remain unclear (Bruss et al., 2018). Here we study the influence of stratification on tidal currents and the significance of internal tides. We collected in-situ data with a vertical thermistor chain, several bottom mount ADCPs across the shelf and a glider extending the transect offshore. We perform harmonic analysis in a moving window to assess the interaction between barotropic tides and stratification and apply methods summarized in (Hall et al., 2019) to analyze internal (baroclinic) tides.

RESULTS AND DISCUSSION

In our data, summer stratification on the Al Batinah shelf develops in March and lasts until October with 2-3 week variation between years. This matches with the findings of Font et al. (2022) based on surface heat flux budgets from glider observations. The stratification reaches its peak of N^2 ~10^{-3} s^{-2} around June. The effect of the Arabian Sea monsoon in July/August is variable between years but generally leads to a reduction of the local SST from around 33° to 30°. The intensity of the stratification can also be modulated by a strong monsoon. Harmonic analysis in a moving window reveals that while the constituent properties of the surface tide (sea level) are stable over the seasons, tidal currents are modulated by stratification. When harmonic analysis is restricted to well mixed winter periods, tidal constituent properties for the flow were similar for two different years.

By combining the time series of the vertical profiles of temperature and baroclinic flow we observe for the first time large-amplitude diurnal internal waves in the coastal ocean near Suwayq. Figure 1 shows the collected data exemplary for three days in September 2022 when stratification was intermediate. In fall, maximum isotherm displacement reaches 10 m (~45 % of the local water depth) with a baroclinic flow of up to 25 cms^{-1}. During peak stratification in June-August the thermocline is shallower and vertical displacement smaller. Frequency analysis confirms that the internal waves are generated by the astronomic tide predominantly in the diurnal band. While the tidal variation of the sea surface is dominated by M_2, both the barotropic tidal currents and the internal tide (vertical isotherm displacement and baroclinic horizontal currents) are dominated by K_1. This is likely linked to different spatial patterns between the diurnal and semidiurnal amphidromes in the region. The depth averaged and low pass filtered energy flux of the internal tides is directed towards the shore. It follows a modulated spring-neap cycle but also depends on the strength of the stratification. In our data the internal wave energy flux was strongest in fall when the thermocline is deeper, N^2 is intermediate and vertical isotherm displacement is largest. Internal tides in turn drive mixing through breaking and shear instabilities and thus reduce downstream (inshore) stratification temporarily.

While internal solitary waves have been observed in the Sea of Oman and mesoscale dynamics are well studied, to date there is no description of internal tides or the interactions between stratification and barotropic tidal currents for the regional shelf sea. The Al-Batinah coast is densely populated with developing infrastructure, a diverse ecosystem and expanding marine uses like sea water desalination, aquaculture, fishing and tourism. Our findings have direct implications for studies of the local marine environment underlining the importance to consider stratification.

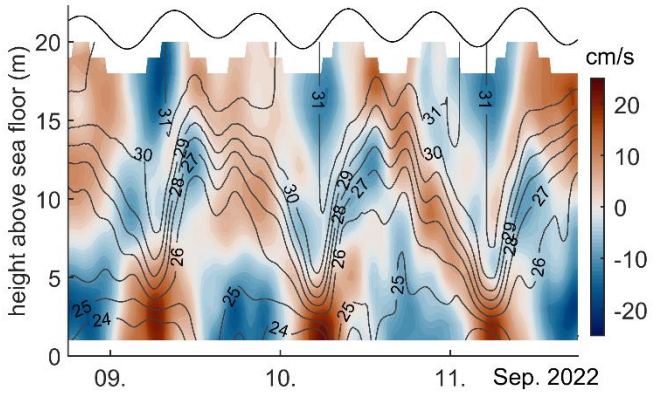

Figure 1: Isotherms and baroclinic cross-shore flow of internal tides near Suwayq.

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