Currents on a Subtropical Shelf under Seasonal Stratification

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Introduction and Objectives

We study the interactions between seasonal stratification and currents on the northern Omani shelf. Local circulation is mainly driven by tides, wind and offshore geostrophy. During summer an intense thermocline develops over the shelf (Claereboudt, 2018). While the influence of thermal stratification on shelf dynamics has been described for other regions, the involved processes along the Oman coasts are still unclear (Bruss et al., 2018). This study tries to answer the following questions for the shallow shelf west of Muscat: how does intense stratification modulate (1) tidal dynamics; (2) the response to wind forcing and (3) residual currents during low-frequency flow pulses.

Data and Methods

We use data from ADCPs, tide gauge stations and satellite derived wind and sea surface temperature. Stationary bottom mount ADCPs were deployed at 9 shallow (18-25m) stations in our study area. The records cover various periods between 2020 and 2022 with the longest continuous dataset spanning 1.5 years. Stratification (buoyancy frequency, N^2) and stability (Richardson number, Ri) are approximated between the surface and the bottom. Rotary spectra and tidal harmonics are extracted from the flow data and vertical normal modes are determined through singular value decomposition. Aperiodic variation is analysed along moving time windows and through wavelet coherence.

Results and Discussion

If harmonic tidal analysis is applied over an entire annual cycle (or longer) the tidal currents that are reconstructed from these coefficients account for less than 45% of the total flow variance within the diurnal and semidiurnal bands. If seasonal variation in the harmonics is considered, this percentage increases to around 75%. Radiative forcing, together with along-shelf flow, is clearly modulating local astronomic tides. Figure 1 shows, exemplary for K1, that variations in N^2 are closely linked to changes in the vertical modes of tidal flow. The variation of the frictional influence between spring and neap cycles is generally damped by strong thermal decoupling. The response to wind forcing is influenced by stratification too. Wavelet coherence between wind and flow decreases more with depth during periods of high Ri. Residual flow and mass transport can become vertically decoupled in summer. At stations close to the coast, we observe a phase shift across the thermocline resulting in opposing longshore transport directions in surface and bottom layers.

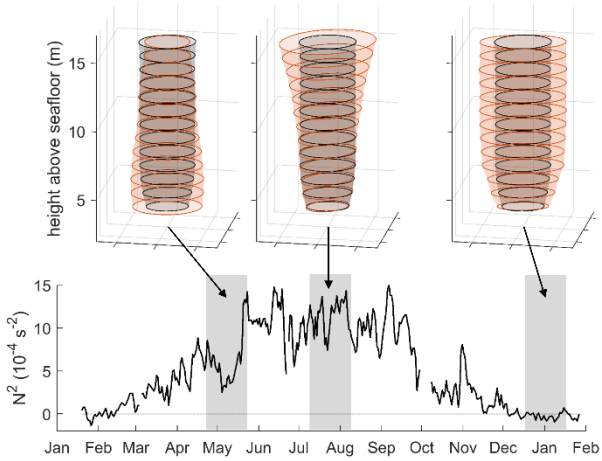

Figure 1: Bottom: buoyancy frequency N^2; top: K1 tidal ellipses, dark: long term analysis, brown: 30-day analysis (grey periods).

References

Bruss, Kwarteng, Baawain, Sana, Chitrakar, Al-Abdali and Al-Habsi (2018) Coastal currents on the northern Omani shelf. 13th ICOPMAS.

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