Interannual variability of the 12-hour tide in the mesosphere and lower thermosphere in 15 years of meteor-radar observations over Rothera (68°S, 68°W)

1) Introduction

Atmospheric tides dominate the wind field of the mesosphere and lower thermosphere (MLT) (Figure 1) and are key agents in coupling the middle and upper atmosphere.

Tidal amplitudes are seen to vary year-to-year and may do this in response to interannual phenomena. However, interannual variability of the polar 12-hour tide is poorly characterised and understood.

![Figure 1: Example of MLT winds. The strong stripes are indicative of tides.](Image)

2) Investigating interannual variability using linear regression

We use meteor radar observations from the British Antarctic Survey’s Base at Rothera, for the years 2005 to 2020, of monthly 12-hour tidal amplitudes at heights of 80 - 100 km. We use a linear regression analysis to identify any correlations between the 12-hour monthly tidal amplitudes and the climate indices for solar flux (F10.7), ENSO (El Niño Southern Oscillation), QBO10 (Quasi Biennial Oscillation at 10 hPa), QBO30 (Quasi Biennial Oscillation at 30 hPa) and SAM (Southern Annular Mode) plus investigating any linear trends with a time term.

We use the linear model below to find any correlations between the tidal amplitudes:

\[ A_{12} = \beta_0 + (\beta_1 F10.7) + (\beta_2 ENSO) + (\beta_3 QBO10) + (\beta_4 QBO30) + (\beta_5 SAM) + (\beta_6 Time) \]

Figures 1 to 6 present the results of the linear regression model, i.e. the coefficients of the model (\(\beta_i\) to \(\beta_6\)). The time-height contours display the response of the tidal amplitudes from the climate index. The solid contours indicate the 90% sig. level from the two-tailed t-test and the dashed contours the 80% level. We have scaled each figure by the inter-decile range \(\alpha\), the difference between the 90th and 10th percentiles.

Any positive correlations give a positive response (red) and any negative correlations give a negative response (blue). We only investigate those regions with significance.

We find that F10.7 solar flux, QBO10, QBO30, SAM and linear trends all have significant responses in the 12-hour monthly tidal amplitudes, whereas ENSO has very minimal correlations.

Key points to note are that solar flux experiences a negative response in summer of \(-4\, \text{m/s}^{-1}\) per au SFU between 85 km and 92 km indicating an increase in solar flux leads to a decrease in tidal amplitudes. Conversely, we find very minimal correlation with tidal amplitudes and ENSO.

3) Results

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7) Conclusions:

We have found that the interannual variability of polar 12-hour tidal amplitudes is correlated with several climate indices. This is especially true of Solar Flux, QBO and SAM with Linear Trends also showing a significant response. Conversely, we do not find a significant correlation with ENSO. Further investigation is needed to understand the mechanisms behind these correlations.