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)

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NERC GW4+ Doctoral Training Partnership

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 is response to interannual phenomena However, **interannual variability of the polar 12-hour tide is poorly characterised and understood.**

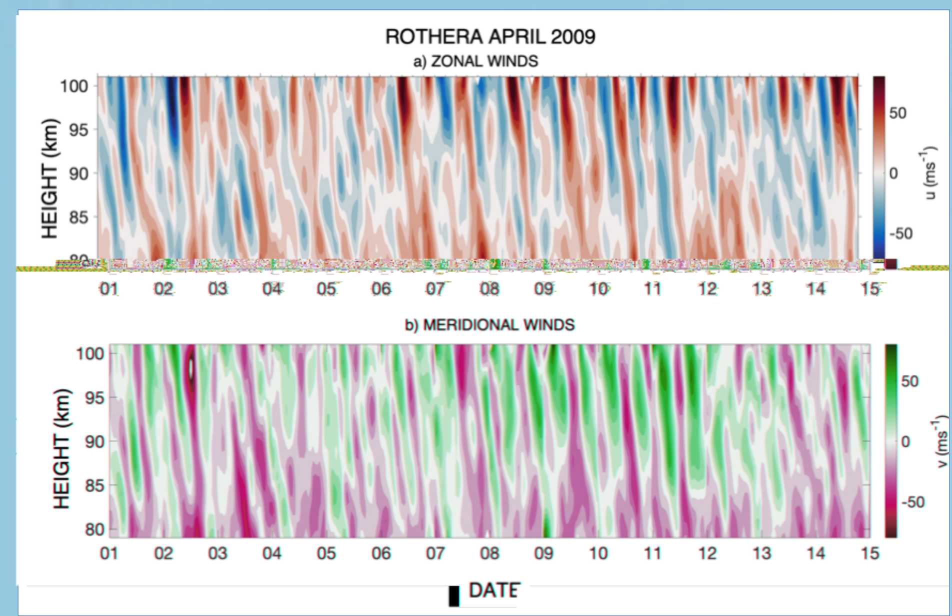

Figure 1: Example of MLT winds. The strong stripes are indicative of tides.

2) Investigating interannual variability using linear regression

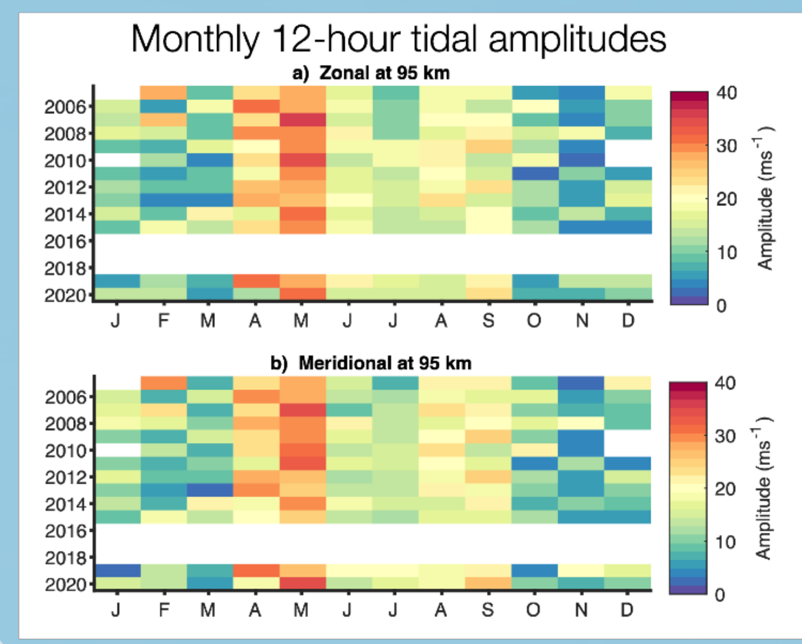

Figure 2: Monthly 12-hour tidal amplitudes at 95 km above Rothera for 2005 to 2020. Each coloured box represents a month.

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.

3)Results

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 (β_1 to β_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 α, 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 $-4\ ms^{-1}\ per\ \alpha\ SFU$ 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.**

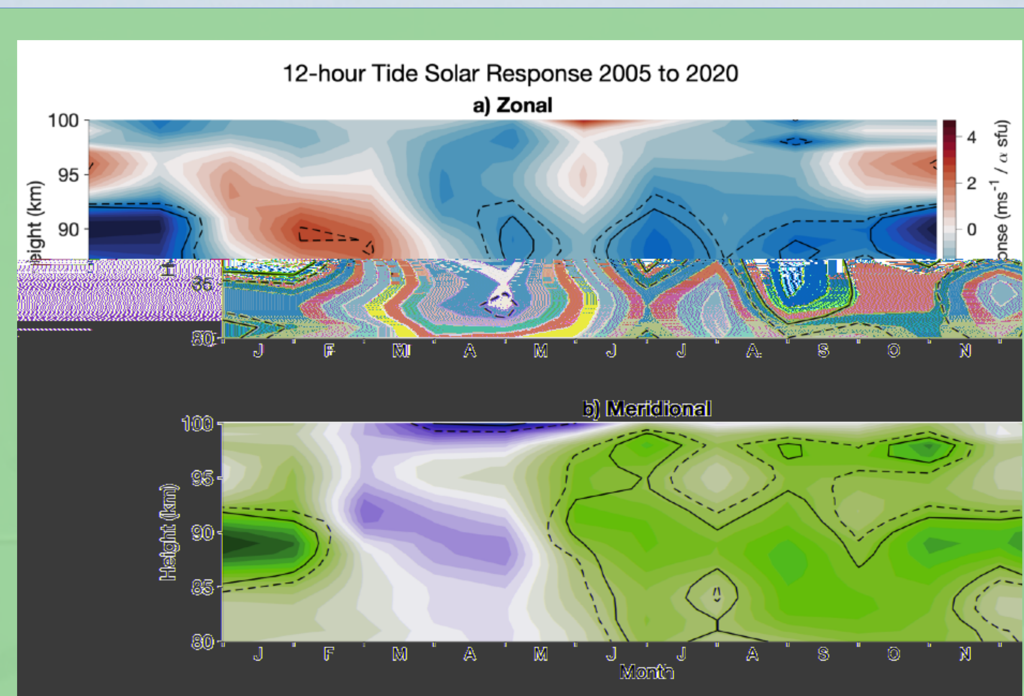

Figure 3: Response of tidal amplitudes to F10.7 solar flux with $\alpha = 57.6\ SFU$

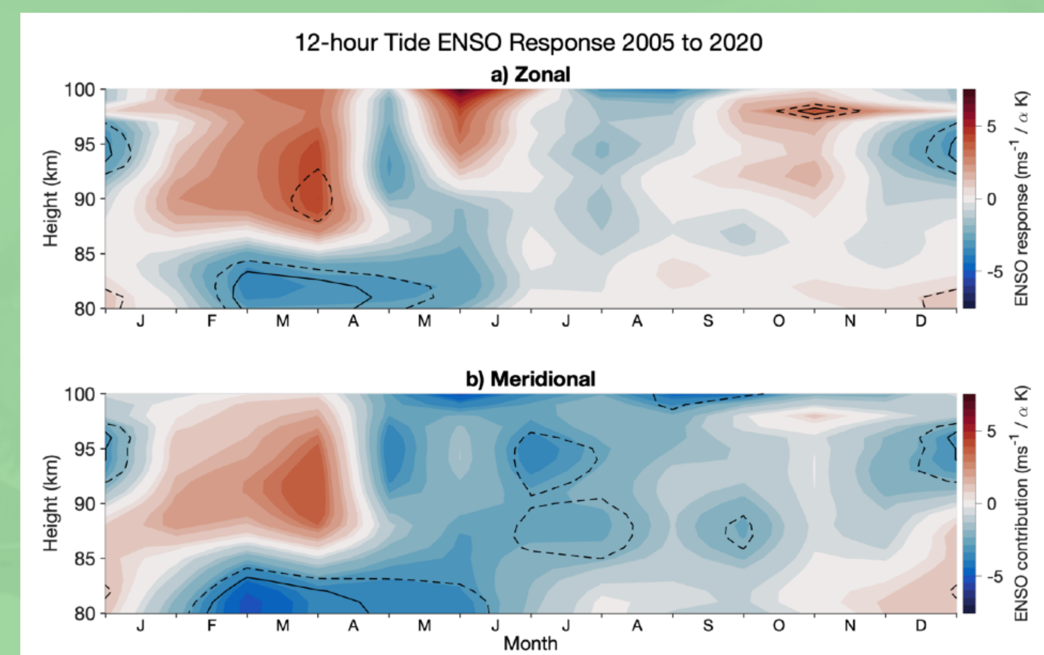

Figure 4: Response of tidal amplitudes to ENSO with $\alpha = 2.67\ K$

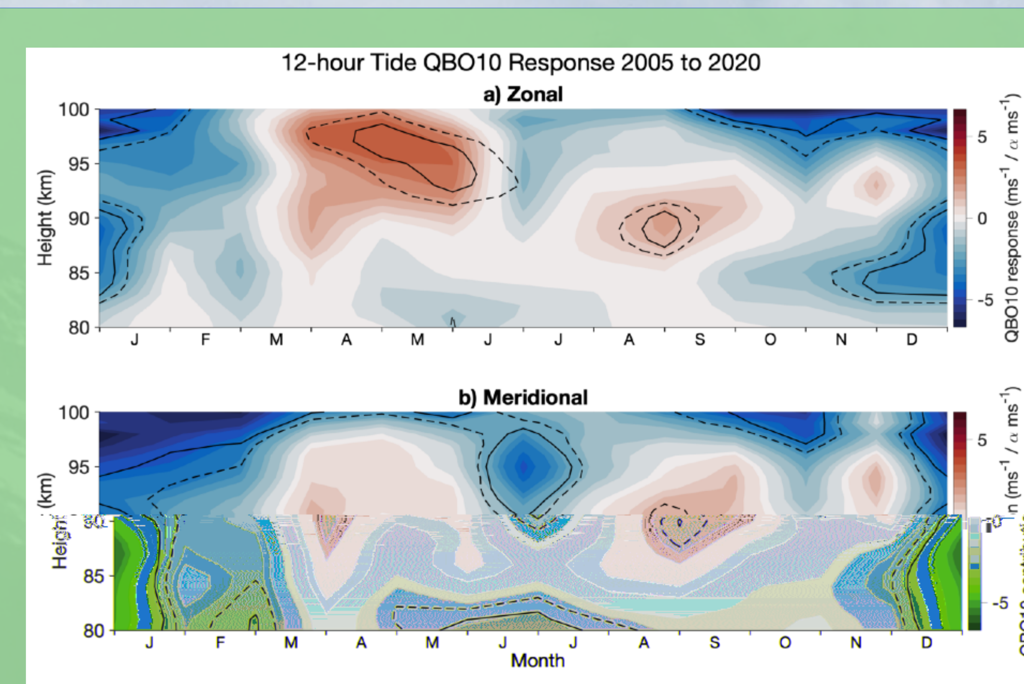

Figure 5: Response of tidal amplitudes to QBO10 with $\alpha = 45.8\ ms^{-1}$

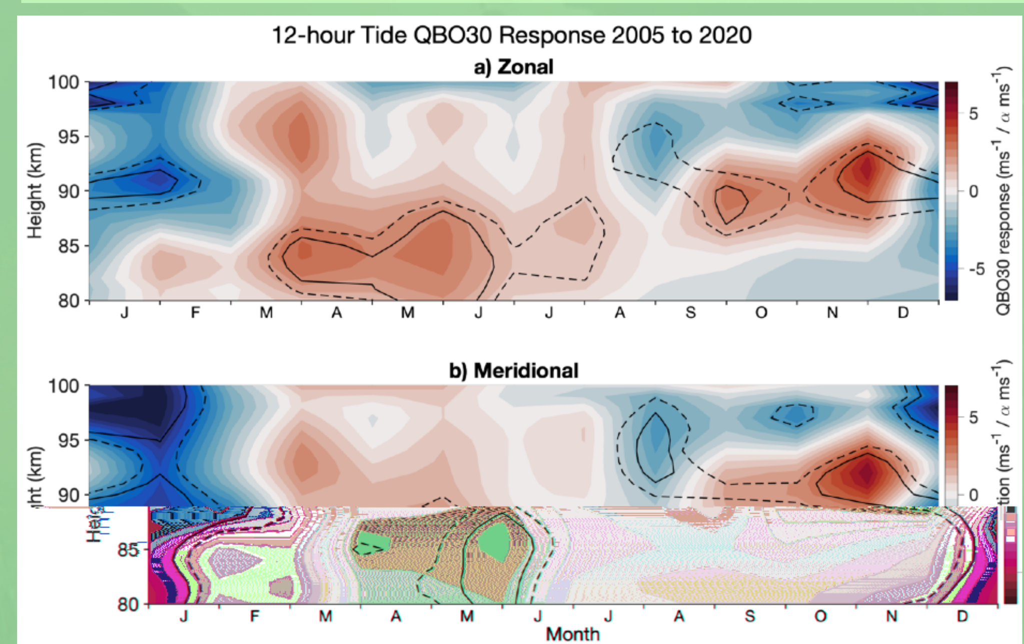

Figure 6: Response of tidal amplitudes to QBO30 with $\alpha = 42.8\ ms^{-1}$

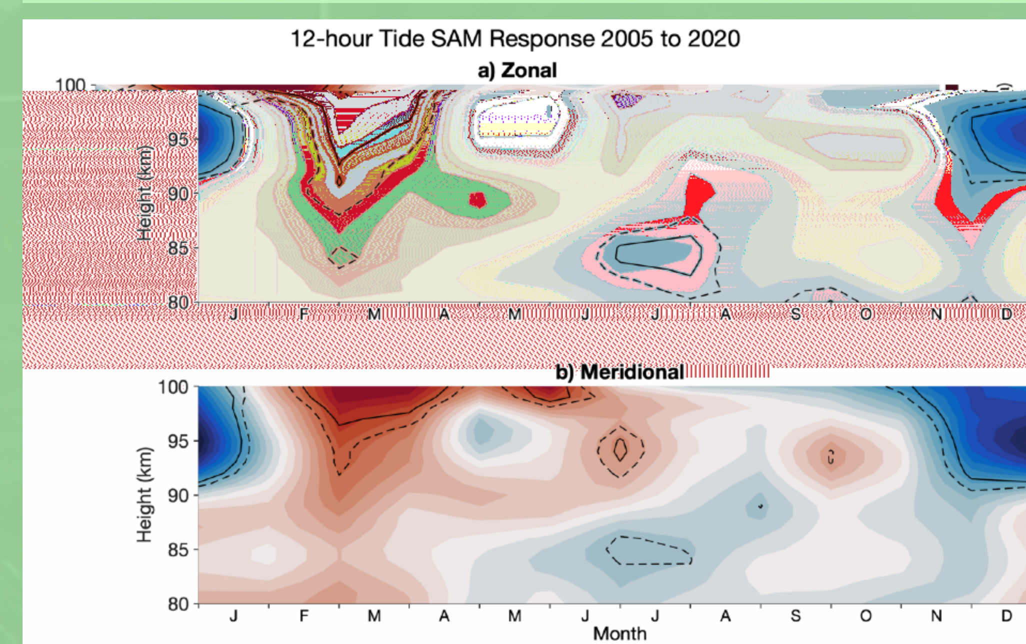

Figure 7: Response of tidal amplitudes to SAM with $\alpha = 4.02\ hPa$

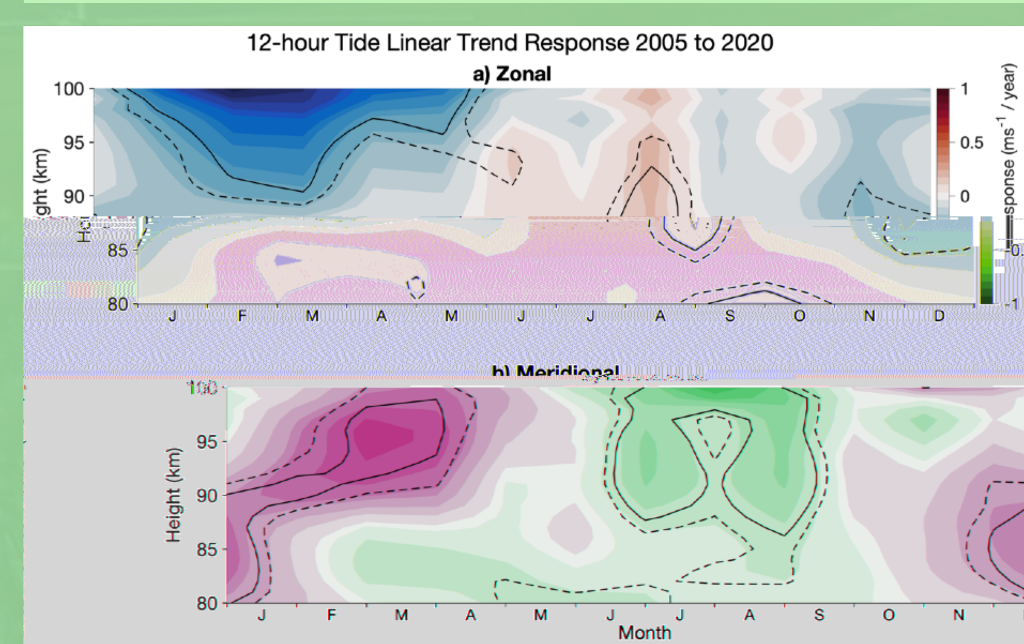

Figure 8: Response of tidal amplitudes to Linear Trends

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. *Read the preprint at* https://tinyurl.com/RotheraTideLR *or by scanning the code ->*

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