Heating Rates from Top-Heaviness Ratio

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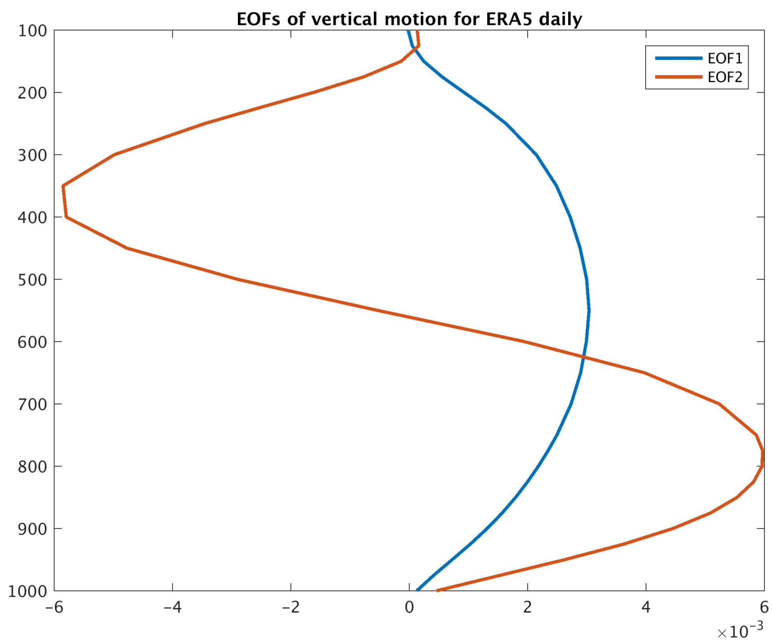

Figure 1: First two EOFs of vertical motion from EOF decomposition of the tropical maritime pressure velocity. The linear combination of them describes 83% of the variance. In order to calculate these, I took 40 years of ERA5 data from 1979 to 2018 over the Maritime tropics and put it into a 2D matrix with height as one dimension and the other three dimensions combined into the second. The vertical velocities are then weighted by the sqrt(dp/p) and I the covariance matrix is calculated. The EOFs of vertical motion are the deweighted eigenvectors of the covariance matrix. The pressure velocity profiles are then regressed against these structure functions in order to obtain the PCs across the entire tropics, including over land.

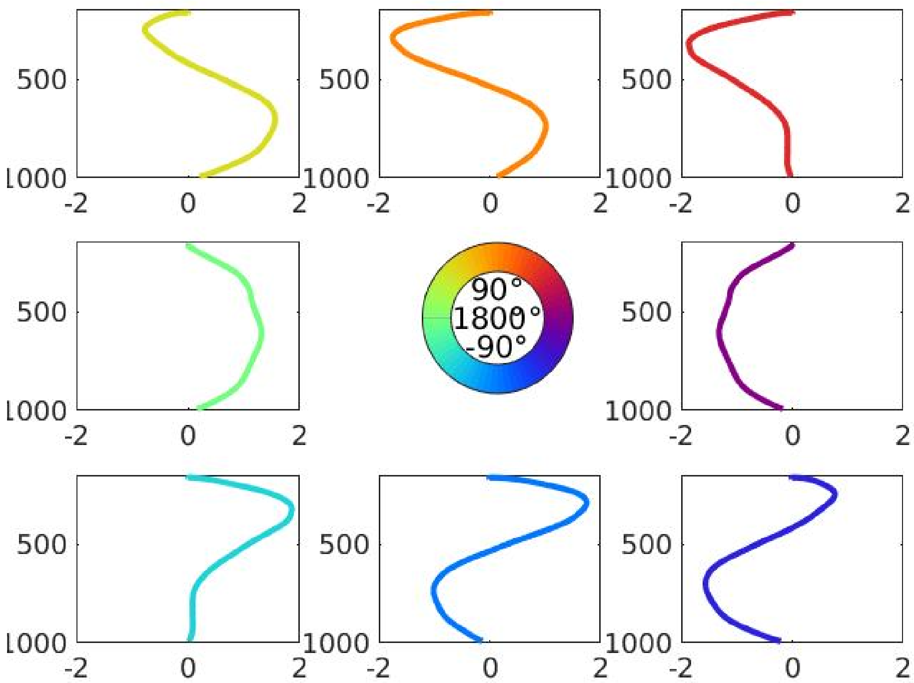

Figure 2: Legend for the Top-Heaviness angle, which is described as the arctangent of the ratio of the second to the first EOF. Angles around zero degrees are neither top-heavy nor bottom-heavy and have upward vertical motion. Negative angles indicate more bottom-heavy profiles and positive angles represent top-heavy profiles.

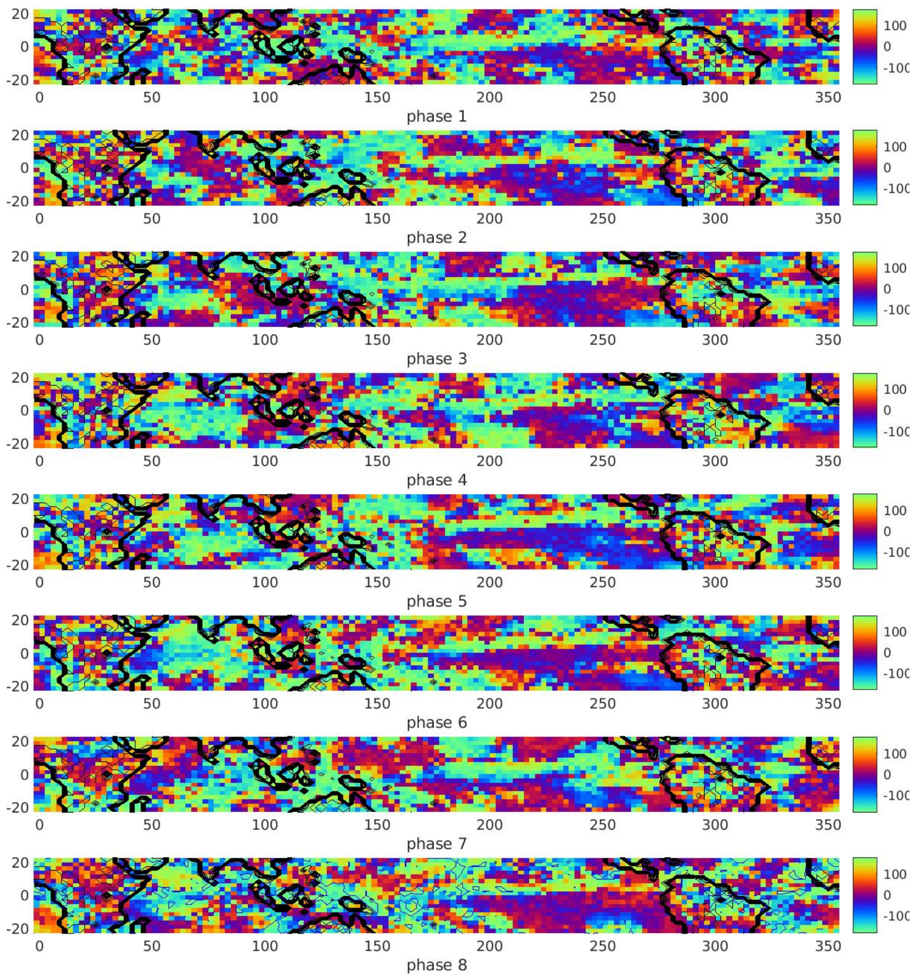

Figure 3: Plot of the top-heaviness angle for the boreal winter months with an RMM index magnitude greater than one. The colors on this figure correspond the legend in the previous figure.

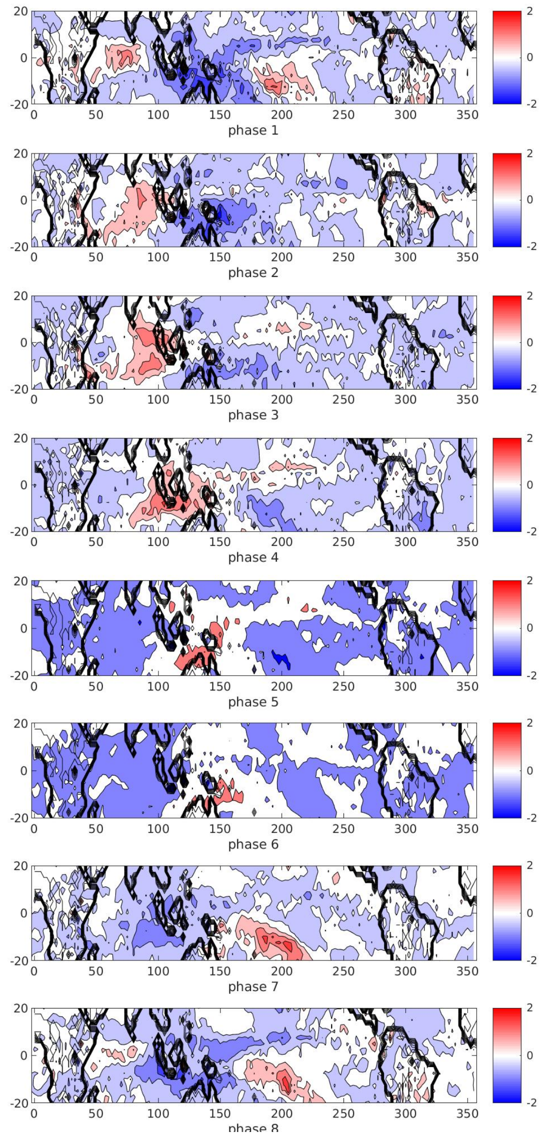

Figure 4: Map of the vertical average of $Q1'_{O1} = o'_1 \omega_1 \frac{\partial \bar{s}}{\partial p} = o_1 S_1$, where $Q1'_{O1}$ is the apparent heating due to the first mode of variability of vertical motion, o_1 is the first PC of vertical motion with the first three harmonics of the annual cycle removed, ω_1 is the first EOF of vertical motion, and $\frac{\partial \bar{s}}{\partial p}$ is the tropical mean dry static energy (DSE) lapse rate. The temporal average is taken over the Boreal winter months and composited by MJO index with $|RMM|^2 >= 1$.

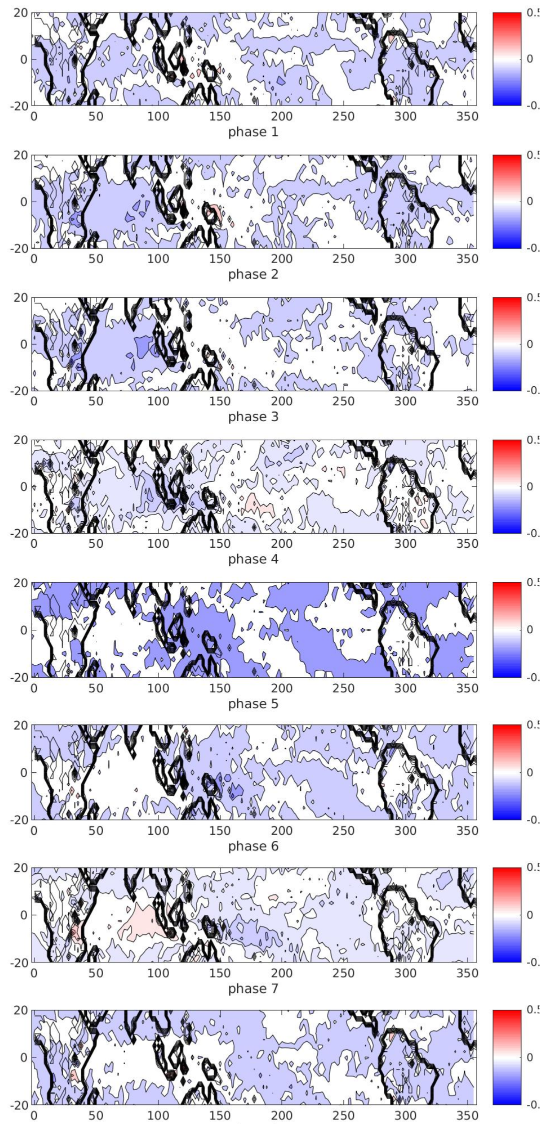

Figure 5: Same as the previous plot but for the second mode of variability, $Q_1(O2)' = o_2' \omega_2 \frac{\partial \bar{s}}{\partial p} = o_2 + S_2$. The temporal average is taken from the Boreal winter months and composited by MJO index with $|RMM|^2 >= 1$.

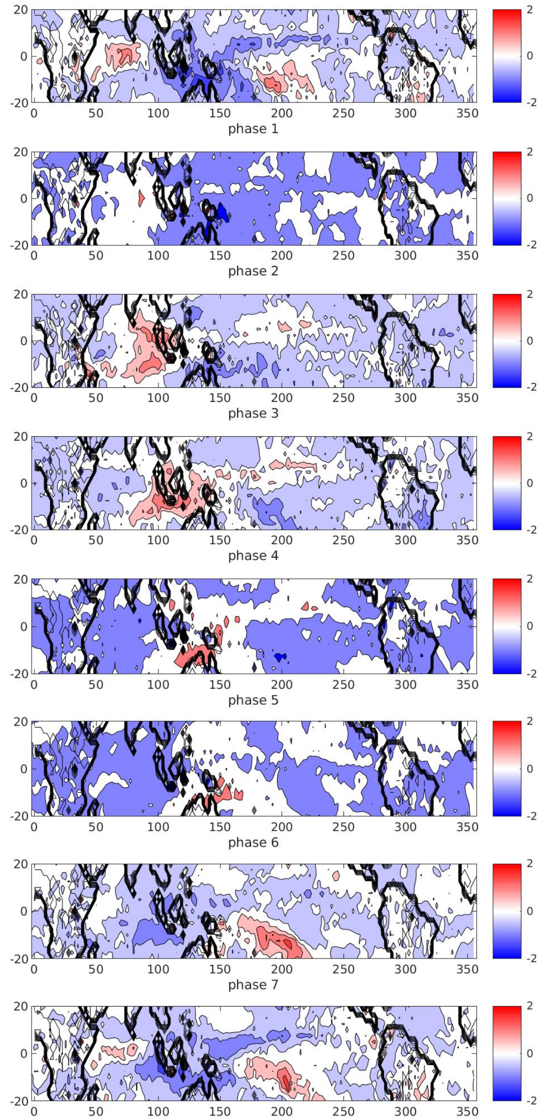

Figure 6: Map of the vertical average of $Q1'_{O1+O2} = o_1 S_1 + o_2 S_2$, which is the apparent heating calculated using both the first and second EOFs of vertical motion combined. The temporal average is again taken over data from the Boreal winter months with composited by MJO index with $|RMM|^2 >= 1$.

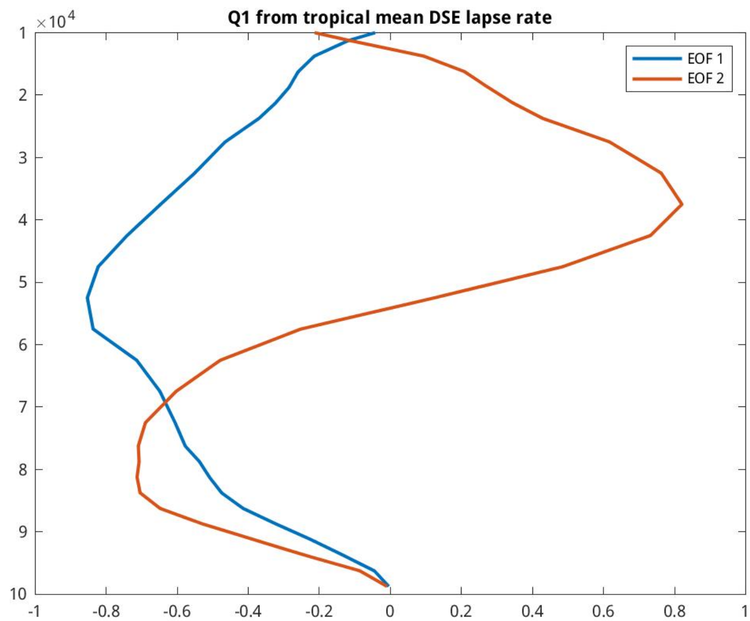

Figure 7: Vertical heating profiles for the first two EOFs of vertical motion for a constant tropical mean lapse rate, $S1$ and $S2$ respectively.