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The impact of southward propagation of the upper-tropospheric Rossby wave activity on the Red Sea trough

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The Red Sea Trough (RST) is an inverted trough of low-pressure system at lower tropospheric levels over the northeast Africa and the Red Sea. The previous research conducted on the RST suggests that when this system is activated, heavy rainfall occurs in large parts of the eastern Mediterranean and southwest Asia. The main aim of this article is to investigate the way Rossby wave activity at the upper level troposphere and its interaction with the lower tropospheric circulation activate the RST.

This study was carried out in three stages: first, the climatological behavior of RST in winter (December to February) was studied and then, cyclones were identified and tracked in the northeast Africa and the Red Sea using a cyclone tracking scheme. In the second stage, the Rossby wave activity flux at the 300 hPa level was considered in the region. Finally, the interaction between the wave activity flux and the RST was investigated. Two critical phases for the wave flux entering the region were considered. The critical positive (negative) phase corresponds to the month when on average the highest (lowest) values of the wave activity flux enter the northeast Africa and Red Sea regions. The results show that, during the critical positive phase, the RST strengthens and extends to the northeast of the Mediterranean Sea and cyclogenesis is increased in the northeast of Africa and especially in the northeast of the Red Sea.

With regard to the divergence of wave activity flux with an associated southward flux, the source of activity needed for cyclogenesis and reinforcement of the RST is provided by the North Atlantic storm track and the divergence core over the Mediterranean Sea. The results of the wave activity time series show that part of the activity from the northeast is integrated with the convergence core of the Mediterranean storm track, leading to enhancement of the cyclones in the northeast of the Red Sea and the extension of the RST to the northeast. But most of the activity joins the flux divergence core of the Mediterranean storm track in the west of the region and results in amplification of Sudan's cyclones and activation of the RST along both the meridional and zonal directions; the important point to consider is that the wave activity flux entering the region is greater in the zonal direction. In addition to the southward propagation of the wave activity, the packets of flux convergence and divergence in the central North Atlantic are tilted in the southwest–northeast direction, indicating the dominance of anticyclonic Rossby wave breaking.

Associated with the upper-level wave activity fluxes entering the region, there is jet enhancement and low-level cold advection from higher latitudes to the tropical and subtropical regions. The difference of RST between the critical positive and negative phases is turned out to be statistically significant with confidence levels of greater than 90%.

Keywords: Red Sea Trough, Northeast Africa and Red Sea cyclones, wave activity flux, critical positive and negative phases, Mediterranean storm track, North Atlantic storm track