The flow and moisture fluxes associated with ridging South Atlantic Ocean anticyclones during the subtropical southern African summer

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Supplementary material

Climatological behaviour of moisture processes

We first discuss the climatological features of geostrophic and ageostrophic moisture processes and consider these in relation to the climatological high pressure system over the eastern South African interior discussed in the Introduction. In Figure 2, the top panel shows that the December, January and December (DJF) climatology of moisture fluxes is similar to those in previous studies (e.g. Reason and Smart 2005; Vigaud et al. 2007; 2009; Blamey et al. 2018) and in modelling studies (Ratnam et al. 2015; Driver et al. 2018).

There exists a region of moisture divergence on land bounded by the box approximated by 18°S to 25°S and 25°E to 35°E. Moisture enters the main land from a south easterly direction at precisely where moisture divergence is located. Some of the moisture fluxes are diverted cyclonically around the Angola low (Howard and Washington 2018) and anticyclonically toward the central interior of South Africa. The latter occur around the anticyclonic circulation and eventually lead to offshore fluxes along the southeastern coast. Case studies, referenced in the Introduction, coupled with forecasting experience have shown that onshore moisture fluxes in these regions are possible, particularly during ridging highs. This is not reflected in the climatology but is consistent with the transient nature of ridging highs.

When the climatological flow and the fluxes are separated into their geostrophic (Figure S1 (b)) and ageostrophic (Figure S1 (c)) components, a slightly more detailed picture emerges. The geostrophic moisture flux divergence is largely located in the Mozambique Channel; east of its total counterpart. This makes more physical sense than that which is observed in Figures S1 (a), where the moisture divergence is located on land. A local ageostrophic moisture flux divergence maximum is almost perfectly co-located with the north-eastern high pressure system, with another on the coast, south of the 30°S latitude line. The ageostrophic moisture fluxes do not contribute to the onshore fluxes from the Channel. There is however clear onshore ageostrophic moisture transport in the southeastern coastal areas. The ageostrophic fluxes are also responsible for transporting moisture deeper into southern Africa, virtually in all directions from MFD centred at about 25°S and 30°E (bottom panel in Figure S1 (b)). The fluxes also appear to be oriented in directions that make acute to right angles with the isobars, consistent with the definition of the ageostrophic flow (Lim et al. 1991; Kwon and Lim 1999).

The separation of moisture processes in this manner shows that, even when time averages are considered, the north-eastern high pressure system plays a role in moisture fluxes in South Africa. The flow associated with it transports moisture into the country from the Mozambique Channel, turn it anticyclonically further in land and also distribute it northwards. The climatology shown in Figure S1 was produced using ERA-Interim reanalysis and was corroborated using JRA-55 data (not shown). The similarity between the two datasets demonstrates that the moisture flux patterns are robust.

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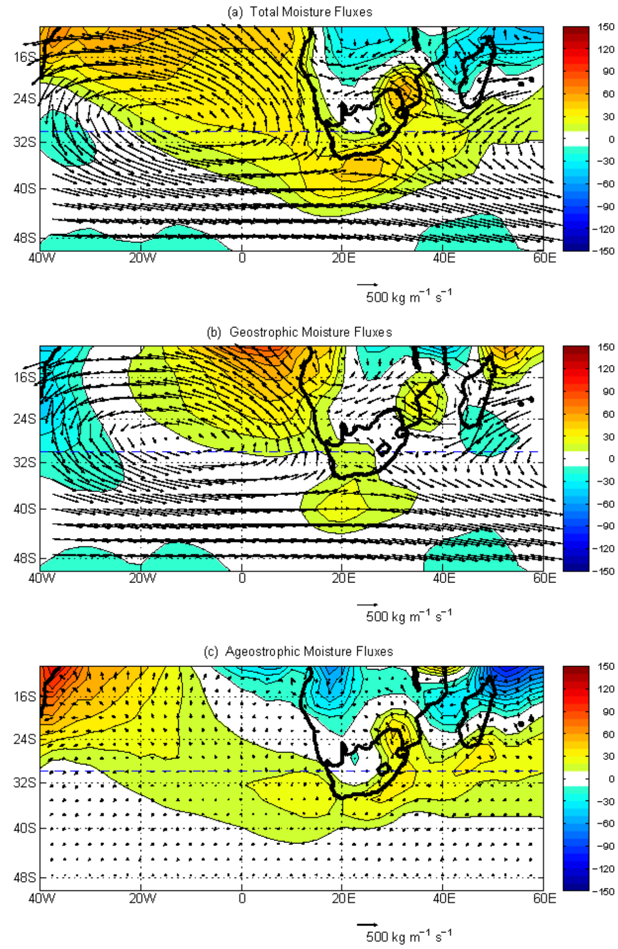

Figure S1: Summer (December - February) climatological means of vertically integrated moisture fluxes and moisture flux convergence by (a) total horizontal flow, (b) the geostrophic flow and (c) ageotrophic flow and. The panels were produced using ERA-Interim reanalysis data. Vector scale = 100 g $m^{-1}s^{-1}$ (black vector) and the moisture flux divergence is plotted in kg m^{-2} for all panels.