Boundary layer dynamics of abrupt seasonal monsoon transitions

Among monsoon systems of the world, abrupt seasonal onset is unique to South Asian monsoon, and limits advance predictability. The Somali jet in the western Indian Ocean is a key moisture source for monsoon and critical to its onset. We have shown how rapid seasonal onset of this jet is tied to emergence of a globally unique and precise quadratic dependence of boundary layer kinetic energy on north-south surface pressure differences, robust to day-to-day variations across years (Figure 1). We have developed theory to show how this comes from balance between flow acceleration and the northward advection of kinetic energy off the East Africa coast. Based on over 40 years of multiple vertically resolved reanalysis datasets on daily and hourly timescales, this work explains abrupt onset and slow retreat of the jet (Figure 2).

R Masiwal, V Dixit, and A K Seshadri, 2023, "Explaining dynamics and rapid onset of the Somali jet through its kinetic energy budget", *Journal of the Atmospheric Sciences*, 80, 833-847, https://doi.org/10.1175/JAS-D-22-0160.1

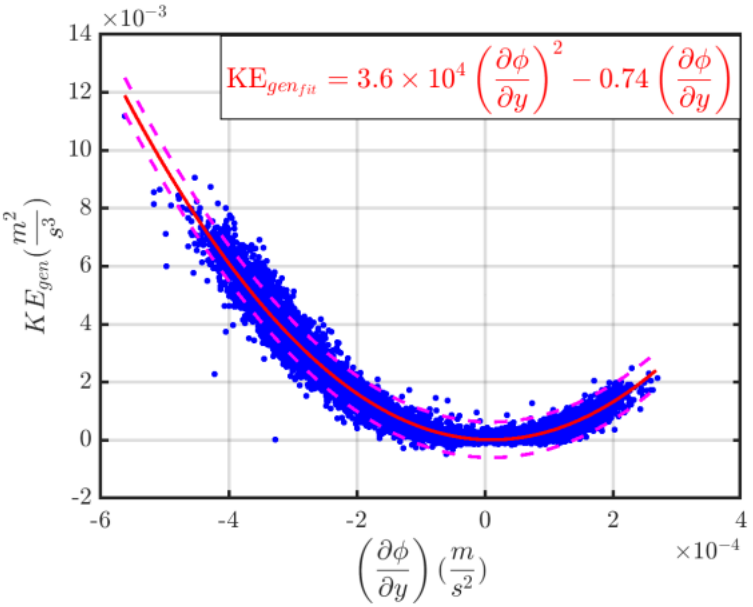

Figure 1: The quadratic relation between the north-south geopotential gradient (horizontal axis) and the generation of kinetic energy (vertical axis) in the advective boundary layer off the East Africa coast (high local Rossby number region), which is responsible for the nonlinear evolution of the Somali jet, on daily timescale for 1979-2020 (Source: Masiwal et al., 2023).

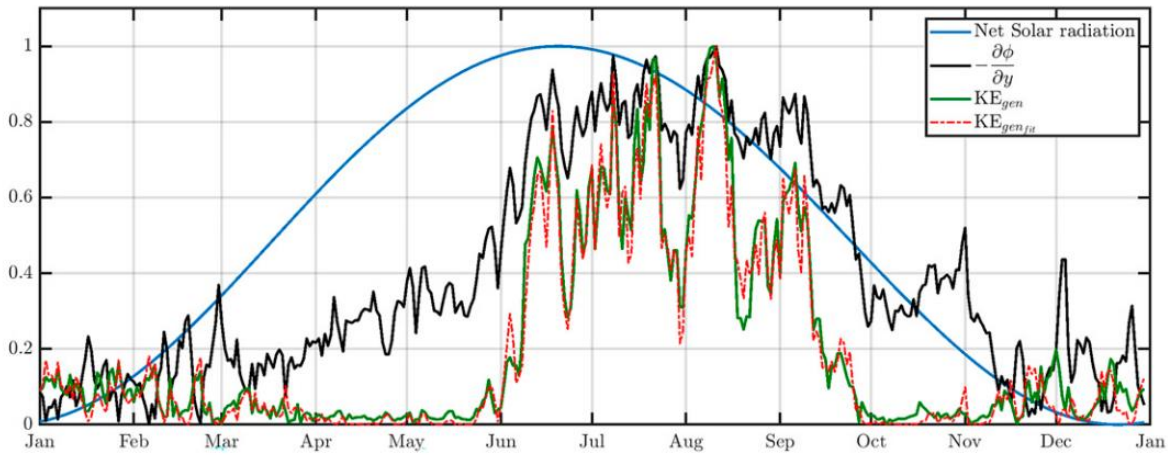

Figure 2: Evolution of net solar radiation at top of the atmosphere, and that of geopotential gradient and the conversion of available potential to kinetic energy in the nonlinear advective boundary layer central to rapid onset, for an illustrative year. The latter is well approximated by the quadratic model in Figure 1 above (Source: Masiwal et al., 2023).