Landslides that are restricted to the soil mantle are often triggered by individual storm events during which it is possible for saturation to occur in minutes to hours. Deep-seated landslides, by contrast, typically have more water storage capacity than is possible to deliver during individual storm events. For this reason, large landslides integrate precipitation variability over seasonal or even interannual timescales, making forecasting failure especially challenging. Here we integrate 8 years of field-monitoring of a seasonally active slow-moving landslide in central California (Oak Ridge earthflow) with groundwater flow modeling to explore how the memory of antecedent rainfall within large landslides impacts their sensitivity to precipitation variability on seasonal and interannual timescales. On seasonal timescales, we show that the onset of landslide motion at Oak Ridge earthflow occurs only after the leading edge of the integrated downward flux of wet season rainfall reaches the water table and triggers an abrupt ~ 10 kPa rise in pore water pressure. The lag between the onset of seasonal rainfall and the onset of landslide acceleration (typically 2-4 months at Oak Ridge) reflects competition between drainage out of the landslide, which creates storage in the vadose zone, and recharge at the surface, which fills that storage. This framework allows us to cast the onset of seasonal landslide motion with a rainfall intensity-duration threshold and shows that the seasonal response time of slow-moving landslides may be controlled by the dry season vadose zone depth (not the total landslide depth, as often argued). To explore landslide sensitivity to precipitation variability on interannual timescales, we use downscaled climate model projections to simulate variably saturated groundwater conditions over 150 years for Oak Ridge earthflow. Notably, we find that increasing precipitation variability (with little change in the annual mean) translates to lower average pore pressures and hence a decrease in future landslide movement. This result is explained by the same vadose zone dynamics that govern seasonal landslide sensitivity. Specifically, during wet periods rainfall exceeds available storage and excess water is diverted to runoff, whereas during droughts drainage exceeds infiltration. Crucially, this means that the cumulative impact of extremely wet years is less than that of dry years due to limited subsurface storage capacity within the landslide relative to winter rainfall. Field observations from Oak Ridge earthflow between 2016 and 2023 cover an extraordinary range of precipitation variability and clearly illustrate the dynamics described above.