Abstract. The direct penetration of the high-latitude electric field to lower latitudes and the disturbance dynamo, both play a significant role in restructuring the storm-time equatorial ionosphere and thermosphere. Although the fundamental mechanisms generating each component of the disturbance electric field are well understood, it is difficult to identify the contribution from each source in a particular observation. In order to investigate the relative contributions of the two processes, their interactions, and their impact on the equatorial ionosphere and thermosphere, the response to the March 31, 2001 storm has been modeled using the Rice Convection Model (RCM) and the Coupled Thermosphere-Ionosphere-Plasmasphere-Electrodynamics (CTIPe) model. The mid- and low-latitude electric fields from RCM were imposed as a driver of CTIPe, in addition to high latitude ion convection and auroral precipitation. During daytime, and at the early stage of the storm, the penetration electric field is dominant; at night, the penetration and disturbance dynamo effects are comparable. Our results also demonstrate that the mid- and low-latitude conductivity and neutral wind changes initiated by the direct penetration electric field preferentially at night are sufficient to alter the subsequent development of the disturbance dynamo.