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The three dimensional current system during substorms

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We present results from a comprehensive statistical study of the ionospheric current system and it's coupling to the magnetosphere during classical bulge type substorms. We identified 116 substorms and determined the global ionospheric current system before and during the substorm using the SuperMAG initiative and global auroral images obtained by the Polar VIS Earth camera. The westward electrojet (WEJ) is centered around 65 / 72 deg magnetic latitude post-midnight / pre-midnight. Thus, we find a distinct latitudinal shift between the locations of the westward electrojet at these local times. The spatiotemporal behavior of the WEJ differs at these two local times. Attempting to explain this significant finding we propose two possible simple current systems. 1) The classical substorm current wedge, which is a single 3D current system. The distinct poleward kink and the different spatiotemporal behavior, however, present considerable complications for this solution. 2) A new 3D current system that consists of 2 wedge type systems: the classical substorm current wedge in the pre-midnight region and another current wedge in the post-midnight region. The latter maps to the inner magnetosphere. To support the empirical modeling we performed Biot and Savart integrations to simulate the ground perturbations. We present results of the statistical study, show typical events, results from the simulations, and discuss the implications for our understanding of the 3D current system associated with substorms.