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Using MMS measurements to validate models of reconnection-driven magnetotail reconfiguration and particle acceleration during substorms

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New data from the Magnetospheric Multiscale (MMS) mission confirms and greatly extends the view that substorms are a configurational instability driven by magnetic reconnection. We have studied in detail a powerful storm period in June 2015 which shows that substorm events seen sequentially by the four MMS spacecraft subsequently feed the powerful enhancement of the radiation belts observed by the Van Allen Probes mission. Several sequences of significant southward IMF along with a period of high (VSW$\geq$500 km/s) solar wind speed occurred following a strong interplanetary shock wave impact on the magnetosphere. We see that substorms provide a "seed" population, while high-speed solar wind drives the acceleration to relativistic energies in this two-step geomagnetic activity scenario. Thus, MMS data help validate models that invoke reconnection as a fundamental driver of magnetospheric particle acceleration. The data for several separate events on 22 June 2015 show that the magnetosphere progresses through a specific, well-observed sequence of energy-loading and stress-developing states until the entire system suddenly reconfigures. Energetic electron fluxes measured by the several MMS spacecraft reveal the clear temporal occurrence characteristics and the obvious relationships to concurrently measured solar wind drivers. This shows that enhancements in substorms are a key first step in the acceleration of radiation belt electrons to high energies as observed subsequently by the Van Allen Probes instrumentation. Thus, this high-resolution observational evidence along with the accompanying modeling has demonstrated that magnetospheric substorms are an important acceleration component within the coupled near-Earth system.