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Tail Ballooning Modes in Global Simulations at Substorm Onset

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It is generally accepted that magnetic reconnection is the main mechanism that dissipates power during a substorm. It is less clear, however, whether the beginning of magnetic reconnection in the magnetotail also signifies the onset of the substorm expansion phase itself, i.e. whether the "outside-in" scenario applies, or if a different process happens first closer to Earth that triggers the reconnection onset in the magnetotail, i.e. the "inside-out" scenario. Global MHD simulations have generally supported the "outside-in" scenario. However, ideal MHD instabilities that could possibly trigger tail reconnection may have been missed due to coarse numerical resolution or due to other numerical effects. Here, we present results from OpenGGCM substorm simulations that clearly show growth of the ballooning mode (large ky) as suggested by our earlier analysis (Zhu et al., 2009), as well as growth of an ideal-like instability that is purely axial, i.e. with zero ky.
The signatures af the ballooning mode in the model is in good agreement with observations, i.e. $\sim$0.5 RE wavelength and associated auroral bead structures, whereas the axial mode appears to be related to entropy anti-diffusion and bubble-blob formation.