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## Coupling techniques in the new high-resolution SHiELD: implicit land-atmosphere coupling.

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As part of the development of GFDL's new high resolution, seamless weather to S2S to climate timescale coupled model, we present the integration of GFDL's atmospheric model SHiELD and land model LM4, enabling a suite of Earth system interactions, including extreme hydroclimate events, ecological droughts, and fires. This work details the implementation strategy and technical challenges of integrating GFDL's LM4 with dynamic subgrid tiling capabilities within SHiELD capable of kilometer-scale global and global-nested simulation. In addition, this effort demonstrates how GFDL terrestrial components designed for implicit flux coupling could be integrated with SHiELD physics designed for an explicit atmospheric solver. The primary objective is to extend SHiELD from an uncoupled atmospheric model, in which land processes are treated as a part of the atmospheric physics package, to a fully coupled high resolution atmosphere-ocean-land-ice-wave model leveraging GFDL's FMS full coupler infrastructure. This enhanced coupling enables more accurate simulations of land-surface feedbacks, cryosphere and hydrological processes, and extreme weather events such as flooding and abrupt changes in aerosols emissions from fires. We demonstrate the model's capability through validation test cases. The results underscore the importance of robust land-atmosphere coupling for high-resolution prediction and provide a framework for future development of fully coupled Earth system models of high resolution for forecast and earth system prediction applications.