Enhanced Low Cloud Representation in E3SM with Framework for Improvement by Vertical Enhancement and Future Plan

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Low level clouds, e.g., stratocumulus, are still poorly represented in E3SM. Recently we have demonstrated that high vertical resolution, of the kind typically used for large eddy simulations significantly improves the low cloud representation in E3SMv1 and that the Framework for Improvement by Vertical Enhancement (FIVE) yields similar improvements while limiting computational cost associated with high vertical resolution. FIVE is a novel method that embeds an auxiliary column with a fine vertical grid in the host model grid column and computes selected one-dimensional processes thereon. For the second phase of the project, we will incorporate an Adaptive Vertical Grid (AVG) into E3SMv1-FIVE, tackle remaining 'stubborn' low cloud types, and develop FIVE towards the global cloud resolving E3SMv4. AVG is a dynamically adjusting option of FIVE in which vertical resolution in the embedded column is modified during run-time to optimize results. Subtropical coastal stratocumulus and Arctic mixed-phase low clouds show resistance to improvement with high vertical resolution. We will explore a novel variation of 3-dimensional mesh refinement, namely a combination of FIVE and the Regional Refined Model for coastal stratocumulus. Arctic mixed-phase low clouds, whose biases are significantly affected by microphysical representation, will be tackled using process-level simulations with boundary conditions derived from E3SM. To adapt FIVE for use in E3SMv4, we have developed a 2-dimensional Hadley circulation model with E3SMv4 physics as a testbed. To maximize the speed-up facilitated by FIVE, a new process-coupling scheme and GPU acceleration will be examined.