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Enabling adaptive mesh refinement for tracer transport in ECHAM6

Yumeng Chen, Konrad Simon, and Jörn Behrens
University of Hamburg, Center for Earth System Research and Sustainability, Department of Mathematics, Germany (yumeng.chen@uni-hamburg.de)

Paleo-climate simulations as carried out in the German PalMod project allow for relatively low resolution due to computational restrictions. Often this resolution is unable to represent important transport processes with sufficient accuracy. Since many of these processes (examples include dust transport, volcanic ash dispersion, etc.) are local in nature, local adaptive mesh refinement (AMR) can accommodate for the increased local resolution requirement without exhausting the computational resources.

In this study we present an approach that adds advanced data structures to an existing earth system model's atmospheric component, namely ECHAM6, in order to enable AMR for the transport scheme. Adopted from the original Flux-Form Semi-Lagrangian (FFSL) scheme in ECHAM6 the new numerical method is still mass conservative and allows large Courant numbers for efficiency. The data structure supports cell-based AMR and ensures compatibility with the overall ECHAM6 data layout.

The performance of the new scheme is demonstrated by idealized test cases that show similar convergence rates of the new AMR scheme and the original method. Furthermore, fewer grid cells are required to attain similar accuracy as on uniformly fine meshes.