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The new physical components of the LMDZ general circulation model: Improvement of the representation of boundary layer turbulence, convection and clouds and impact on climate variability.

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Over the last decade, a thorough research effort has been undertaken by the development team of the general circulation model LMDZ (the atmospheric component of the IPSL Earth System Model) to include parameterizations of physical processes known to play a key role in the life cycle of convection and clouds. In particular, a representation of boundary-layer thermals has been introduced in the LMDZ model, in order to account for the large part of heat and moisture transport they carry out and to improve the representation of cumulus clouds, which form at their top and contribute to the pre-conditioning of deep convection. Cold pools are another key component of the life cycle of deep convection. They are generated through the evaporation of falling precipitation, spread at the surface and trigger new convection at their edges. The impact of thermals and cold pools on the triggering and maintenance of deep convection is now represented in the convection scheme. The statistical cloud scheme has also been developed so that within each model gridbox, the subgrid-scale variability of total water related to small-scale turbulence and thermals is represented by a bi-gaussian PDF, while the variability related to deep convection is represented by a skewed generalized log-normal PDF. These new parameterizations have been developed and tested in the single column version of the LMDZ model through systematic and extensive comparisons with observations and high resolution simulations. We present here the first 3D simulations run in forced and coupled modes as part of the IPSL climate model. Key improvements obtained in 1D case studies are confirmed in the 3D version of the model, especially a better representation of low-level clouds and of the diurnal cycle of continental convection. The impact of this better representation of local and small-scale processes on the simulation of climate variability is then examined, focusing on the Inter-Tropical Convergence Zone, the intra-seasonal Madden Julian Oscillation, the inter-annual (El Niño Southern Oscillation) variability, and the thermohaline circulation.