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Planetary boundary layer feedback on the climate sensitivity: Estimations derived from large-eddy simulations

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In a single compartment model representation, the earth's climate sensitivity is a ratio of the system characteristic response time to its heat capacity. The earth's heat capacity, C, is a rate of change in the earth's heat content related to the rate of change in the air (or sea) surface temperature. Analysis of the observational data sets (S. Schwarts, JGR, 2007) revealed that global C is closely associated with the depth of the ocean mixed layer. Over continents and ice covered seas however, C is considerably less and should be associated with the highly variable depth of the planetary boundary layer (PBL). As climate models reproduce the PBL rather poor (J. Cuxart et al., BLM, 2006), it is interesting to derive C and hence climate sensitivity estimations from turbulence-resolving models through large-eddy simulations (LES). LES explicitly resolve the turbulent fluctuations in the PBL and its evolution. It makes possible to calculate the surface temperature increment over a diurnal cycle in response on incremental change of the PBL control conditions, such as e.g. radiative heat flux divergence at the surface. In absence of other feedbacks, the LES give a unique opportunity to compute changes C induced by changes of the PBL depth. Moreover, since the PBL depth is an integral measure of the turbulent mixing intensity and sensitive to the changes in the lower atmosphere static stability (Zilitinkevich and Esau, QJRMS, 2003), LES permit estimation of the surface air temperature sensitivity to the dynamical circulation factors, e.g. temperature lapse rate of the mean wind speed, which are not related directly to the radiation imbalance caused by the greenhouse gas absorption. Here, I utilize a database of more than 100 experiments with the LES

code LESNIC to obtain abovementioned estimates of the climate sensitivity and the strength of the PBL feedback under dry clear-sky conditions. Such conditions are relevant to drier areas of the continents and colder areas in high latitudes where actually the enhanced temperature warming signal has been detected (IPCC, 2007). The obtained preliminary results suggest that the PBL feedback is dominant climate feedback for the PBL shallower than about 200 m that is nocturnal and long-lived polar PBLs. Under certain conditions, the feedback may reverse sign. It happens when the entrainment heat flux from the free atmosphere overwhelm the flux from the surface.